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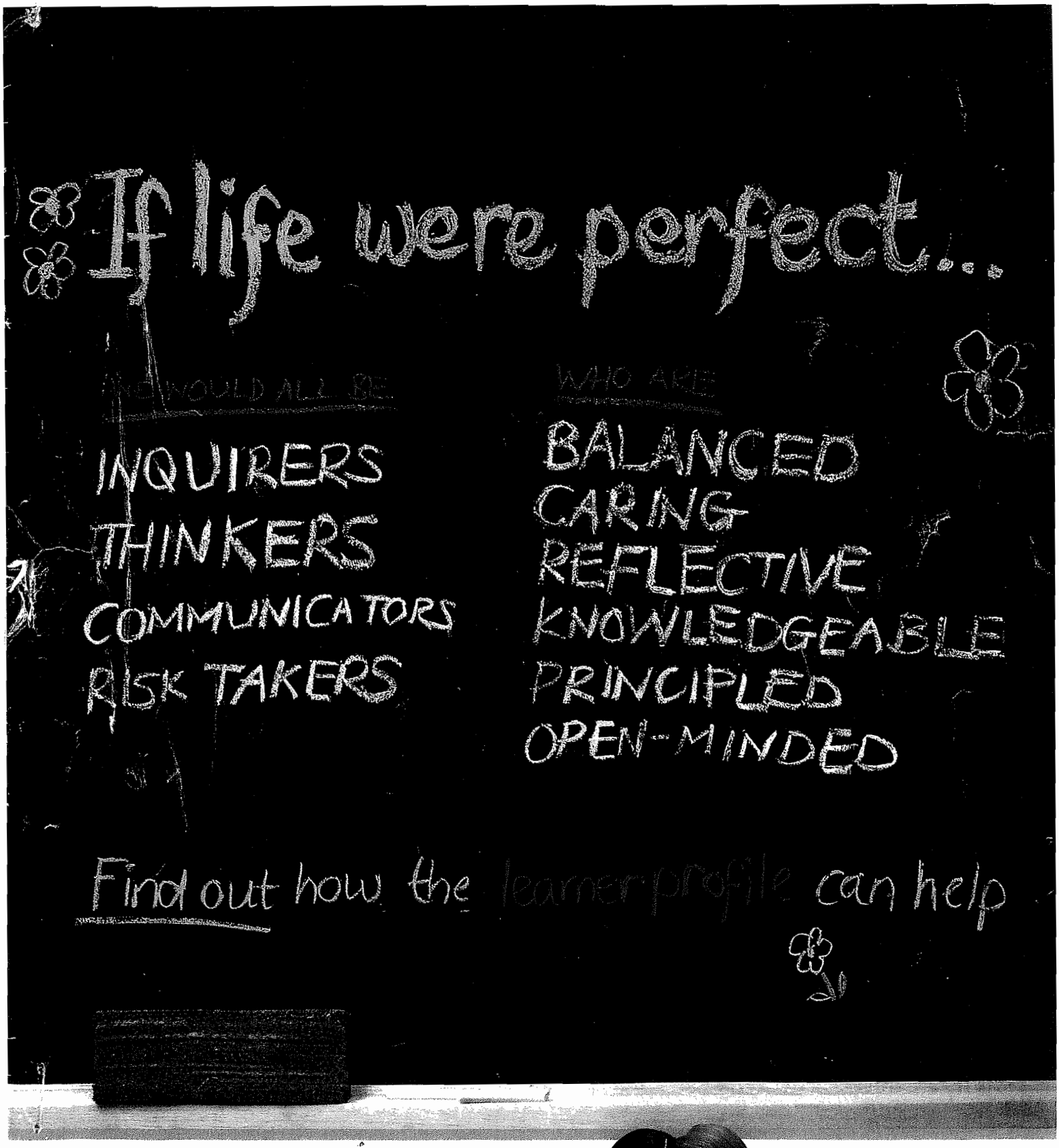

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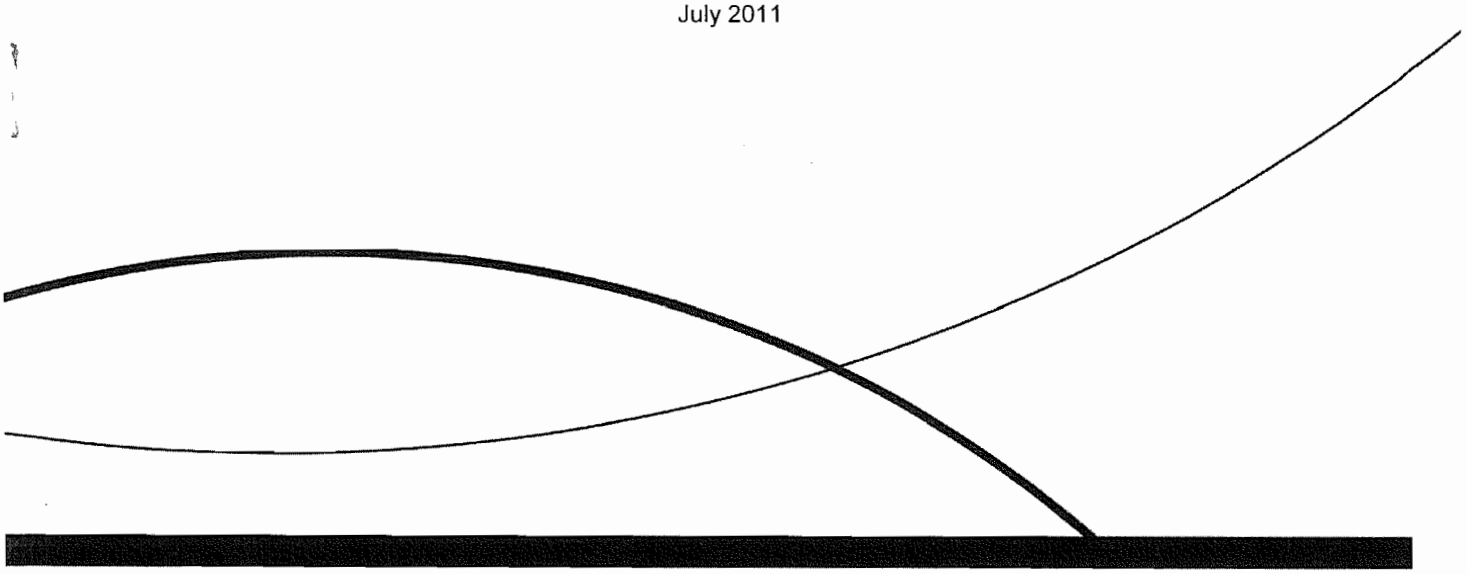
Group 4 (experimental sciences) Curriculum review

REPORT TO SCHOOLS

Chemistry

July 2011



Group 4 Curriculum Review Meetings

Biology, Chemistry, Physics and Design Technology

Cardiff, UK April 7- 9 2011

REPORT TO SCHOOLS

Introduction

The Diploma Programme requires that all curriculums are reviewed in a seven year cycle. This is to ensure that each curriculum is fit for purpose in a changing world and incorporates the latest educational research as well as lessons learned through evaluation of the existing curriculum. This document is a report on the outcomes of the first meetings of the separate group 4 subjects – biology, chemistry, physics and design technology- that took place over three days at Cardiff UK on April 7-9 2011. Teaching of the new courses arising from this review will begin in September 2014 with the first examinations in May 2016. The review is both a challenge and an opportunity with participants preparing courses which have to be relevant up to the year 2022.

The four meetings took place over the same 3 days to facilitate common sessions and ensure that a common approach was being taken on group issues. In addition, much was gained by the cross fertilization of ideas that this allowed.

Part 1 of this report will address the common issues and the outcomes arising from these.

Part 2 will be separate accounts of the individual subject sessions.

Part 1 Recommendations requiring common action across group 4

The aims of the meeting were to begin to act upon the recommendations from the all group 4 review meeting held in Oct 2010 and subsequently approved by the Diploma Review Committee. (DRC) What follows applies to physics, chemistry and biology. Recognizing its distinctive nature within group 4, design technology has been allowed to develop its own unique solutions to many of the recommendations.

Recommendation 1 (from DRC) Reduce number of written papers from 3 to 2 for SL to make G4 SLs compatible with other diploma subjects.

The Assessment department presented the assessment policy on the above. i.e. all other diploma subjects have only two written components at SL. Several possible models had been prepared for the meeting. Wide ranging discussion took place as the adjustment for SL has implications for HL. The HL model is still being discussed. Here is a possible SL assessment model.

SL Assessment model

Component	Overall weighting (%)	Duration (hours)	Format and syllabus coverage
Paper 1	30	1	40 multiple-choice questions (15 common with HL)
Paper 2	50	2	Section A : Structured answers (long and short) based on the core Section B: Option
IA	20		

Recommendation 2 Design a new SL science and technology course for the vast majority of students (who may not study science again) but will need to understand scientific issues arising in their lives upon which they need to make reasoned judgments.

This course would run alongside the current group 4 SLs and be developed with the same timeline and in phase with the other SLs.

This recommendation was addressed at a separate science meeting held on April 10 -12 2011 and a separate report on this has been published on the OCC.

Recommendations 3 and 4

3 Nature of Science (NoS) element in all G4 courses.

This should be the overarching principle and the starting point of the curriculum development process.

4 Audit existing courses at SL and HL and reduce "content" in each course as they are currently overloaded. Maintain depth and rigour.

A grid consisting of various elements of NoS was used to conduct an audit in each separate subject that demonstrated the feasibility of using NoS as the overarching principle. This audit grid, after modification and refinement, will be applied in developing the new guide content including the reduction of content. See further details in each subject report.

Recommendation 4 will be carried out in the separate subject meetings.

Recommendation 5 (and 8)

5 Develop a new type of Internal Assessment (IA).

This will be carried out for both existing SL/HL courses and the new science SL course. As at present, this IA scheme will be common to biology, chemistry and physics.

Some assessment of experimental work can be done through the written papers (design, analysing, concluding and evaluating data).

Design technology has its own separate solution

8 PSOW form remains (possible new name)

40/60 hours will still be required for practical work. See curriculum models below.

A prolonged discussion on new IA types along with the results from the teacher questionnaires brought up lots of ideas.

Three possible models for a new IA were presented, based on discussions over the first two days. One model was a hybrid of the other two and was rejected as being too complex and unacceptable to the assessment department. Another model was rejected as it did not assess practical work. The model proposed is for one, open-ended practical investigation with generic criteria that will allow both a wider range of activities satisfying the varying needs of the three subjects and more agreement on the marks awarded as a result of the application of the criteria. It would be 20% of the overall assessment. The criteria would need to reflect the learner profile and the overarching NoS theme.

Further "minor" recommendations

Recommendation 6 Align style of existing Group 4 aims with MYP (middle year programme) ones stressing student centred nature.

For example, the diploma programme aims are in the following style:

It is in this context that all the Diploma Programme experimental science courses should aim to:

whereas MYP aims state:

*The aims of the teaching and study of MYP sciences are to encourage and enable **students** to:*

Recommendation 7 Rewrite Aim 8 as it has too many elements. Make it more central to the courses.

The aims will be rewritten to reflect their student centred nature. Recommendation 7 is still to be looked at. A more consistent approach across all three subjects in the extent and nature of aim 8 references will be adopted.

Recommendation 9 New way of presenting the guides including an emphasis on the Nature of Science as the overarching principle.

A possible model for a new presentation of the guide to avoid the emphasis on assessment was generally accepted. This may group assessment statements so that lower order assessment statements (1s and 2s) are subsumed into higher order ones (3s). The nature of science aspect would also feature prominently in each topic. A sub group will be established to finalize this.

Recommendation 10 Continue work of last review as far as diploma wide issues and cross curricular links are concerned – make more explicit and central to the courses.

This will be carried out in future meetings. Diploma-wide issues such as TOK, international mindedness, the continuum with MYP will be further developed and refined. Links will be

made with topics in other diploma subjects within and across hexagon groups and real world applications of subject topics will be emphasized.

Recommendation 11 Number of subject specific options 1 NOT 2 (from 4, not 8)

Each subject has chosen their four options and a method will be devised for ensuring parity between the four options.

Recommendation 12 Previous option slot time used for the interdisciplinary common theme - the nature of science.

This 15/22.5 hours would be used to address NoS in the core, the AHL and the option. It would encompass NoS aspects both within and outside a specific subject. It would also address scientific literacy.

The existing curriculum models for SL and HL, based as they are on 2 options being studied would be modified as follows.

Curriculum model SL

SL	Total teaching hours	150
Theory		110
	Core	93
	Option	17
Practical work		40
	Investigations	30
	Group 4 project	10

Curriculum model HL

HL	Total teaching hours	240
Theory		180
	Core	93
	AHL	61
	Option	26
Practical work		60
	Investigations	50
	Group 4 project	10

Part 2 Chemistry subject meeting

Participants

The participants involved in the recent chemistry curriculum review meeting represented a wealth of International Baccalaureate (IB) experience and chemistry expertise. There were six participants, five of whom were either current or past IB teachers; all are involved in marking examination papers and/or moderating IA; four are examination paper authors; others were members of the senior examining team. Participants were selected to provide representation from different IB regions and different school types. There was a good gender balance and a mix of teaching experience. Staff from the International Baccalaureate Curriculum and Assessment (IBCA) office were also present.

Before the Meeting – Research and Questionnaires

Prior to this meeting, the Curriculum Subject Area Manager (CSAM) had prepared a substantial report on chemistry education worldwide which examined chemistry specifications from a wide variety of countries and education systems. Questionnaires addressing the present course were made available to IB chemistry teachers via the Online Curriculum Center (OCC). A separate questionnaire was sent out to university chemistry departments across the globe. The university questionnaire allowed faculty to comment on the suitability of the current chemistry curriculum to prepare students for continuing studies in chemistry. Unfortunately both of these questionnaires had very poor returns with only six of the university questionnaires and 23 of the teacher questionnaires being available for the meeting. The deadline for completion of both questionnaires has been extended and these responses will be considered at the next chemistry subject meeting. The findings of this research were shared with participants prior to the meeting on a web based collaborative environment and considerable discussion took place online, on the contents of these reports and questionnaire response, prior to the meeting.

Meeting Results

Wide ranging discussions took place over the three days in a whole group 4 setting (biology, chemistry, physics and design and technology) and in various smaller subject and cross-curricular groups. The internal assessment (IA) recommendations that arose from these discussions will be further addressed at distinct IA review meetings that are scheduled to take place later in 2011.

Nature of Science

The first task of the chemistry subject team was to consider the 'Nature of Science (NoS)' and where aspects of NoS are being addressed and where they could be addressed in the current syllabus. Here NoS was defined as being comprised of several key features – instrumentation, creativity, patterns and benefits and outcomes. The team began with what they thought would be the most difficult topic to find examples of NoS - organic chemistry. The team soon provided evidence that there were already a great number of aspects of this topic that already addressed NoS and also provided examples of what could be added, modified or removed in order to increase the emphasis of NoS in organic chemistry. They

produced a list of examples (by no means exhaustive) for this topic as shown in Table 1. The consensus was that there are examples of NoS throughout the chemistry curriculum but the teaching emphasis/approach may need to be modified so that NoS is made an integral aspect to class in addition to the teaching and learning of chemistry ideas. Work will continue on aligning the remainder of the syllabus with the emphasis on NoS.

Table 1 – NoS alignment for Topic 10 and 20 – Organic chemistry

NoS classification	Addresses NoS at present	Not matching with NoS	To be included
Instrumentation and Quantification as a tool	• Stereoisomerism • Analytical methods • Empirical/molecular formula		• Analytical methods • Breathalyser (IR, dichromate)
Creativity, Serendipity, Flashes of Intuition and Thematic Imagination	• Polymerization (PTFE, etc.) • Benzene • Tetrahedral (tartaric acid) • Reaction Pathways (at present needs to be changed if kept)	• Reaction pathways (Perhaps change)	
Discrepancies, Patterns and Models, Hypothetical/deductive	• Tests – saturation, unsaturation • Homologous series • Models • Mechanisms • Isomerism • Classification of organic reactions	• S_N1 S_N2 reactions • Elimination pathways	• Benzene chemistry
Benefits and Outcomes			• Applications and context • Synthetics

Subject Outline

The chemistry subject team then considered the constraints within which the new curriculum must fit. There will still be a common core to SL and HL, AHL extra or extension material and a choice of four optional topics with one being studied by candidates. **It was decided that there would be no change in either the basic structure or topic headings in either the core or AHL section of the syllabus, although there would be some rearrangement and/or deletion of subtopics.** This rearrangement and/or deletion of subtopics will be an ongoing process and work will continue in upcoming meetings of the chemistry subject team. Responses from the chemistry subject questionnaire will also be considered during this process. Please refer to page 41 of the current subject guide for the syllabus overview which remains unchanged.

The main changes in the subject outline are found in the options section of the syllabus. Sections of the present option A – Modern analytical chemistry will be dispersed throughout

the core and AHL sections. It was felt that at present not all students are exposed to this important topic in chemistry and by dispersing the analytical option within the other topics, students will be able to more easily make the link between theory and application. Aspects of the current environmental chemistry option will be placed either in the core or as part of the other options.

Four new options were developed. It should be noted that this development of these options is to be considered ongoing. Central to the discussion on the development of the options was the idea that it was important to create options so that they were integrated instead of being made up of standalone topics that were nitpicky in detail. The participants felt that these newly developed options were combinations of applications and "real chemistry". The four options were also developed so that there were both biological and physical applications. The four options (titles are also a work in progress) are Materials, Chemistry for Biologists/Nutrition, Chemistry for Physicists and Medicinal and Pharmaceutical. In order to achieve a greater level of parity across the options the team first decided on what were key ideas and skills that all students should be exposed to and then made sure that the options could be written so that these ideas and skills were met. The draft plan for the options can be found in Table 2. Please note that for option B, the Chemistry for Biologists and Nutrition topics are to be combined to make a single option.

Table 2 – Option plan

Key Skills and Ideas	A. Materials (modernize, explosive, dyes, pigments, paints surfactants, nanotechnology, plastics, modern metals)	B. Chemistry for biologists	B. Nutrition	C. Chemistry for physicists (Energy/chemical change – oil industry, polymers, nuclear, solar cells, battery technology, fuel cells)	D. Medicinal and Pharmaceutical
Quantitative	• Fuel cells and catalysts • Fractional distillation (Raoult's Law) • Cost of extraction	• Respiration (energy capture) • Buffers (blood, soil, ocean) • Enzyme kinetics • Protein pump	• Iodine numbers • Carbohydrates • Energy content	• Molar heat capacities • Nanotechnology • Lattice energies	• Synthesis drugs • GCMS • Analysis of chromatograms • Equilibrium extraction
Analytical	• Crystallography • Chromatography	• Pigment extraction • Protein crystallography	• Chromatography • Electrophoresis • Food colouring • Chelating agents • Dyes and pigments	• Interstellar chemistry (spectranalysis) • Crystallography • NMR (biomedical applications)	• Carbon 13 NMR • Chromatography • Mass Spec • Redox • IR
Environmental	• Oil industry, toxicology, nanotechnology • Recycling • Economic	• Ocean habitat • Carbon, nitrogen cycle	• Depletion of food sources • Organic debate • Packaging and transport • Soil/minerals • Water (fluoride debate)	• Natural versus synthetic oils • Energy sources – solar cells • Super-conductivity	• Cannabis • Economic • Toxicology • Bioinformatics • Waste, solvent,
Applications and benefits, risks	• Oil industry (polymers, catalysts, superconductors, biomaterials, fuel cells) • Molecular modeling • Funding	• Biotechnology • Oil spill cleanups	• Balanced diet • Food technology (behind the scenes) • Additives • Vitamins • GMOs • Coordination chemistry	• Nanotechnology • Molecular nature of force and friction • Natural and synthetic oils • Muscle movement (ion exchange)/bio-physics	• Analgesics • Antacids • Nicotine • Caffeine • Isotope Use (cancer drugs)
Synthesis and	• Synthesis of biomaterials, mechanisms	• DNA structure • Steroids • Contraceptive pill	• Structures – condensation and hydrolysis	• Nanotechnology • Organic conductors • Synthesis of materials	• Structures of compounds • Drug design (computational chemistry)

pathways	• Carbon nanotubes	• Lipid chemistry	• Spoilage (free radicals) • Food technology • Additives • Cholesterols	• Liquid crystals • LCD, LED, Plasma	• Synthesis (functional groups, isomers, chirality) • Mechanisms
Chemical Spine/ Fundamental chemistry/Chemical Concepts	• Paramagnetic and ferromagnetic • Polymer	• Polymer	• Polymer	• Polymer	• CAS – drug development in developing countries • Case studies • Alcohol/cancer link/youth • Drugs in sports • Polymer
Current research					
ICT					
International mindedness			• Food labelling • Vitamins		
TOK				• Quantum numbers • Orbitals as waves	• Thalidomide

The design criterion in chemistry internal assessment

Deciding upon the most suitable strategy for assessing the design criterion is one of the most important decisions for the teacher of IB chemistry. The questions to be considered when implementing a design strategy are as follows:

- How much lesson time is to be allocated to the task?
- How many students are in the teaching group?
- What resources are available for use by the students?
- Will the task stimulate a spirit of inquiry in the students and promote thinking skills in addressing a complex problem?
- Do the students have the prerequisite skills and knowledge base to address the task in a meaningful manner?
- Can the teacher ensure that, when completing the written phase of the investigation outside the classroom, the students work independently?

The answers to these questions will differ according to each school's environment, but some common principles remain.

- Students are more likely to work independently if their design task is unique to them.
- Students are more likely to work independently if they have confidence in their own ability to complete the design task successfully.

To help students to complete a unique task independently, teachers could do the following.

- Set a common task for all students only when the task potentially has many different independent/control variables. For large class sizes, it can be difficult to ensure a wide enough range of different approaches.
- Set a limited selection of maybe two to four different design tasks in a circus of simultaneous experiments, during which only a small number of students address each task. Each task should have a range of potential independent variables to investigate, thereby allowing each student to make a unique choice. This arrangement means that limited equipment and materials can be shared out more evenly. The students can be rotated around the different tasks each time design is to be assessed.
- Set a wide-ranging list of design suggestions or encourage students to come up with their own ideas. This approach can generate truly individual work but it can be difficult for the teacher to organize and effectively supervise large classes.

If the teacher takes the approach of collecting and marking the designs prior to the action phase, then a wide-ranging list of tasks can be set, but students can then be teamed up for a common action phase in the event of materials being in short supply. (This does, however, weaken the sense of ownership a student has for their investigation and limits the effectiveness of the problem-solving learning opportunity.)

If a teacher is confronting the problem of many students simply reciting designs from web-based sources or lab manuals, it may be necessary to allocate supervised class time to the task of writing up designs.

To increase the students' self-confidence in their ability to accomplish the task independently, it is important for the design-setting strategy to recognize that they need to have some familiarity with the concepts and techniques involved. Some suggested approaches are as follows.

- Set tasks that are an advance on prior work from pre-IB years or earlier in the IB course. However, it is inappropriate to set students essentially the same task as previously (for example, to ask students to investigate the effect of concentration on the rate of a given reaction when the students have already investigated the effect of temperature on that same reaction system). Similarly, teachers should avoid setting a task that is already covered completely in readily available literature such as the class's laboratory manual (for example, to investigate the factors affecting the rate of reaction between sodium thiosulphate and hydrochloric acid). It is not uncommon to find whole classes responding in an identical manner to such a design task, and such an occurrence if left unaddressed will be acted upon by the moderator. In such cases it is better to restrict assessment to DCP and CE.
- Give students a practical session to familiarize themselves with the techniques required prior to the writing up of their design. They can use this session to try out materials, to develop a workable procedure, and to see if their proposed independent variable has any measurable effect. If the teacher

takes the opportunity during this session to ask the students to explain their thinking behind what they are planning to do, then it is subsequently easier to ascertain whether the student has produced the final written design independently. Also, at this stage, students can be encouraged to think more deeply if they are considering undertaking an oversimplistic investigation.

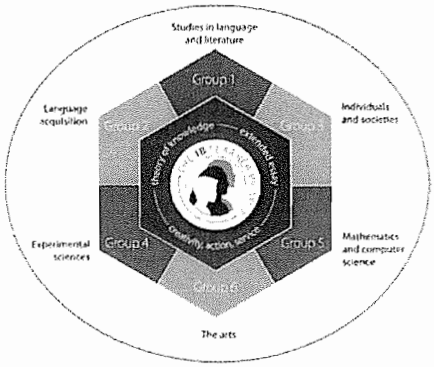
Once a teacher has decided on a strategy for assessing design, acceptable instructions need to be given to the students. Normally this takes the form of a brief description of the general problem(s). Aspect 1 of the design criterion requires students to formulate for themselves the focused problem or research question, as well as to identify independent and dependent variables, and relevant controlled variables. It is essential that the teacher gives the students only an open-ended prompt, and the topic must allow for a variety of different approaches.

Most commonly, there are two types of appropriate teacher prompts.

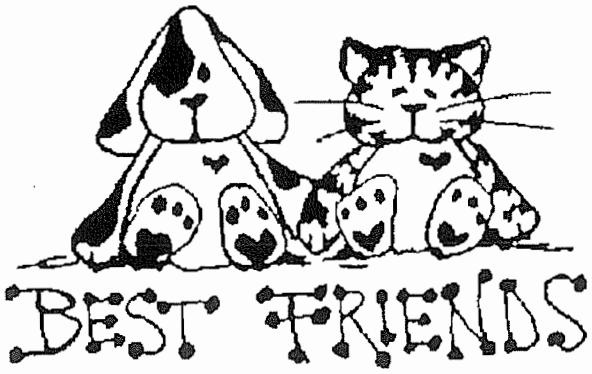
- Firstly, the **dependent variable is given** by the teacher, and the student must select the independent variable as well as appreciate the controlled variables. An example here is when the teacher tells the student to investigate one factor that affects the output potential from an electrochemical cell.
- The second type of prompt is where **neither the dependent nor independent variables are given** but the **system to be investigated is identified**. An example of an open-ended teacher prompt would be "Investigate an aspect of an esterification reaction".

Since it is necessary for students to identify an independent variable, that is, a variable whose value is changed in a controlled manner, it is **inappropriate** to set a task simply to measure a physical constant or quantity, for example, the molar mass of lighter fuel gas. If in response to an open-ended prompt a student decides to determine a chemical or physical constant, the measurement of which requires the identification and manipulation of an independent variable (such as an activation energy, where temperature must be manipulated between trials), then this is an acceptable quantitative extension of qualitative research. However, a teacher's instruction **cannot** direct the student to this because such an instruction would effectively identify the independent variable for the student.

INQUIRY-BASED LEARNING + IB DP



FRIENDS? OR FOES?



DP SAIBSA – 11TH FEBRUARY 2012

PRESENTER: GILLIAN ASHWORTH

Teaching and learning

This section is a brief statement of the key principles of teaching and learning that underpin the three IB programmes. The pedagogical approaches described here are based on a constructivist understanding of how children learn. Constructivism is a theory of cognition, now widely used and accepted, that asserts that knowledge is not passively learned but actively built and refers to approaches that recognize the importance of engaging and challenging existing mental models in learners in order to improve understanding and performance.

In the light of a constructivist understanding of teaching and learning, IB programmes are designed to stimulate young people to be intellectually curious and equip them with the knowledge, conceptual understanding, skills, reflective practices and attitudes needed to become autonomous lifelong learners.

Above all learning for IB students should be rigorous, engaging, challenging and should equip students for life in the 21st century.

The purpose of teaching and learning: Teaching for understanding

The central purpose of teaching and learning is to help students develop and extend the concepts they use to understand the world, solve problems and communicate. Knowledge consists of bodies of information. A new concept is developed when meaningful connections are made between bodies of knowledge and other existing concepts, and the making of those connections leads to a deeper understanding of the world and an improved ability to solve problems. Humans are by their nature makers of meaning. The challenge of excellent teaching is to help students achieve genuine and sophisticated understanding that helps them function effectively and independently in an increasingly complex world.

Central to teaching for understanding is the use of guiding or key questions. The act of framing these open or generative questions causes teachers to focus on the reasons why they are teaching that particular body of information and thus it helps them ensure that the knowledge and skills they are teaching are relevant and meaningful. The use of questions in the PYP to frame the units of inquiry, in the MYP to focus learning through the areas of interaction, and to structure learning in theory of knowledge and the academic isciplines in the DP have all proved to be highly effective in developing conceptual understanding in students of all ages. Enabling students to understand key concepts and develop conceptual thinking requires that IB teachers keep their eyes firmly fixed on the big or central ideas and requires them to take every opportunity to help students make those important connections.

Effective learning for life in the 21st century recognizes that:

- the knowledge base is increasing rapidly, requiring learners to process and evaluate knowledge, not just acquire it
- the world is changing rapidly, requiring learners to anticipate the unknown and adapt to change, not just respond to it
- employment prospects increasingly require an ability to transfer skills and learning learning to work and solve problems collaboratively is becoming as important as learning to work individually
- how the brain learns is becoming better understood with implications for teaching and learning that need to be respected
- developing self-confidence in learners, as well as academic competence, is essential if learners are going to be able to function effectively; affective dispositions in addition to cognitive competence are central to learning
- constructive critical thinking is a tool necessary for individual and collective survival; students must learn to be able to distinguish sense from nonsense, propaganda from truth and make their own well-informed judgments.

Approaches to teaching a Diploma course

Good teaching practice is not specific to the IB or to any programme of study. However, the IB philosophy and principles have implications that teachers need to be aware of in their teaching practice and that might be different from other teaching contexts they have experienced.

There are a wide range of teaching strategies and approaches that should be used in the classroom. Individual teachers and students have their preferred learning and teaching styles and some styles are more prevalent in different cultures and national settings. What is essential is that each student is actively engaged in classroom activities and that there is a high degree of interaction between students and the teacher, and also between the students themselves.

Learning should focus on meaningful questions and contexts and the voice of the learner is considered to be as important as the voice of the teacher. The teacher is viewed as a supporter of student learning, rather than a transmitter of knowledge, making use of questions and tasks that help the student work in their "zone of proximal development". This term, originally used by Vygotsky (1962 and 1978), represents the range of achievement that lies between what the student can manage on their own and what they can manage with the support of the teacher. The emphasis is on engaging and challenging the learner's existing mental models in order to develop a greater depth of understanding and to improve performance.

Whole-class instruction that encourages open discussion, in which the teacher challenges student thinking and demonstrates a range of appropriate responses, can be extremely effective. In comparison, a teacher who lectures, and involves students as passive recipients rather than active participants in the classroom, is likely to be less effective. Overemphasis on lecturing is incompatible with the aims and principles of the Diploma Programme. Teachers should use a variety of different approaches at different times, employing a mixture of whole-class, group and individual activities that are representative of the learner profile.

The learner profile stresses the importance of inquiry. Students are expected to develop their natural curiosity, together with the strategies and skills needed to become autonomous lifelong learners. Students are also expected to think for themselves so that they can approach complex problems and apply their knowledge and skills critically and creatively to arrive at reasoned conclusions or answers. Diploma Programme courses specify a large amount of content, with the area of study often defined in considerable detail. It is the way in which content is presented in class that is critical. The aims and objectives of each course emphasize the importance of students investigating answers for themselves. IB assessments are designed to reward evidence of independent student thinking leading to considered individual responses, so it is important that students practise these skills at every opportunity. Different subjects also provide a number of opportunities for students to design their own inquiry, with the extended essay as the ultimate structured inquiry exercise.

Learning how to become an effective learner requires students to realistically evaluate and regulate their own learning and performance. "Metacognition" is a term used to refer to reflective thinking strategies, attitudes and other competencies used to monitor and control learning. Metacognitive strategies and skills can be nurtured in a supportive learning environment that focuses on the affective as well as cognitive competencies identified in the learner profile. In order to become independent learners, students need to develop powers of reflection, self-confidence and self-awareness, a willingness to communicate ideas without fear of losing face, and a willingness to take risks and be open-minded.

The Diploma Programme: From Principles into Practice – pg 37

Students learn best when...

Tick all of the statements below which you think are important in completing the statement above:

'Students learn best when...'	Important?	How does can this happen in my subject?
• their prior knowledge is considered to be important		
• learning is in context		
• context is relevant		
• they can learn collaboratively		
• the learning environment is provocative		
• they get appropriate feedback to support their learning		
• diverse learning styles are understood and accommodated		
• they feel secure and their ideas are valued and respected		
• values and expectations are explicit		
• there is a culture of curiosity at the school		
• they understand how judgments about learning are made, and how to provide evidence of their learning		
• they become aware of and understand how they learn		
• metacognition*, structured inquiry and critical thinking are central to teaching in the school		
• learning is engaging, challenging, rigorous, relevant and significant		
• they are encouraged in everything they do in school to become autonomous lifelong learners.		

* Metacognition = 'thinking about thinking', reflecting on one's own thought processes

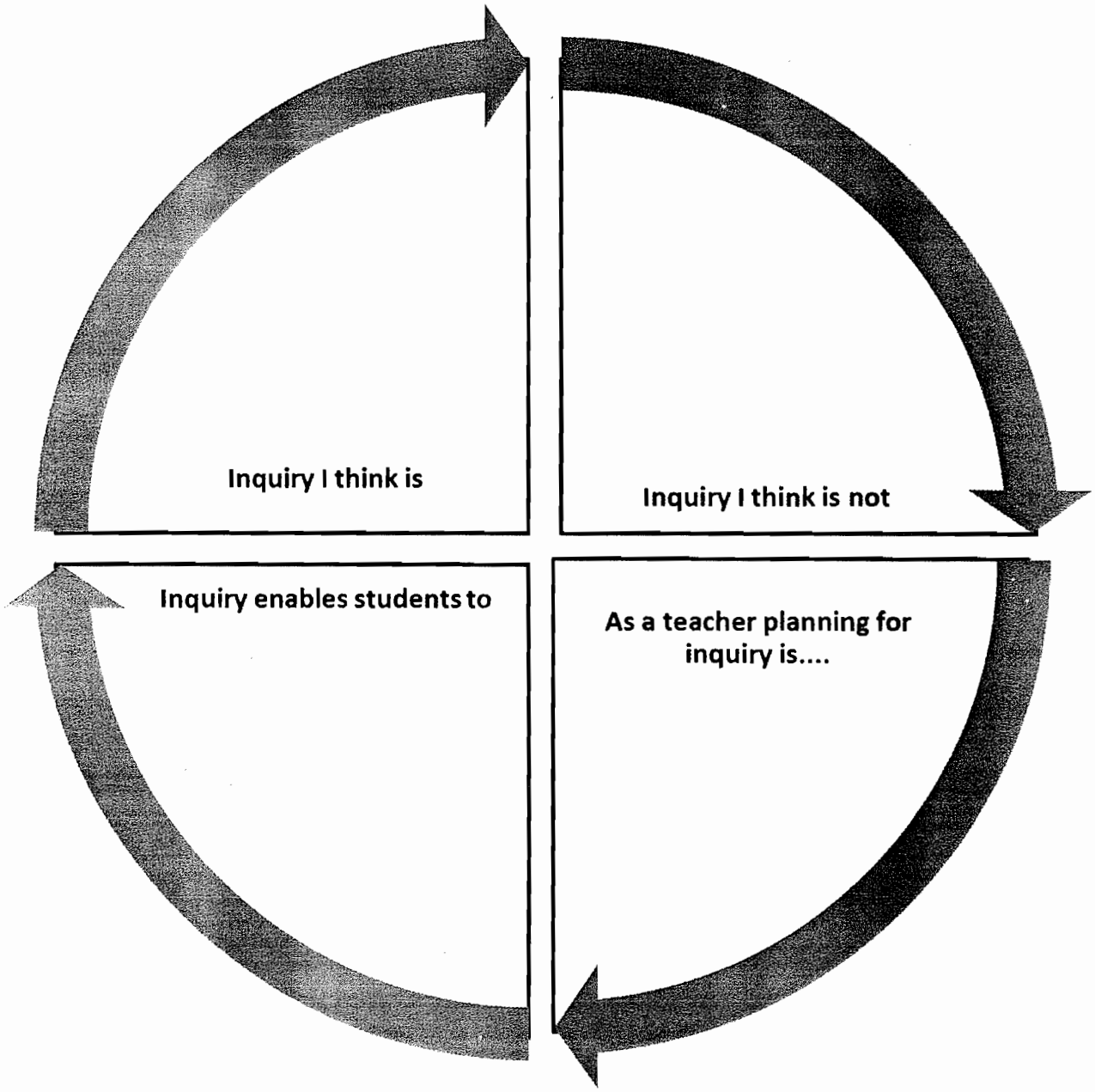
Section C: Curriculum

Standard C3: Teaching and learning

Teaching and learning reflects IB philosophy.

1. Teaching and learning aligns with the requirements of the programme(s). a. Teaching and learning at the school addresses all of the aims and objectives of each subject.	
2. Teaching and learning engages students as inquirers and thinkers.	
3. Teaching and learning builds on what students know and can do.	
4. Teaching and learning promotes the understanding and practice of academic honesty.	
5. Teaching and learning supports students to become actively responsible for their own learning.	
6. Teaching and learning addresses human commonality, diversity and multiple perspectives.	
7. Teaching and learning addresses the diversity of student language needs, including those for students learning in a language(s) other than mother tongue.	
8. Teaching and learning demonstrates that all teachers are responsible for language development of students.	
9. Teaching and learning uses a range and variety of strategies.	
10. Teaching and learning differentiates instruction to meet students' learning needs and styles.	
11. Teaching and learning incorporates a range of resources, including information technologies.	
12. Teaching and learning develops student attitudes and skills that allow for meaningful student action in response to students' own needs and the needs of others.	
13. Teaching and learning engages students in reflecting on how, what and why they are learning.	
14. Teaching and learning fosters a stimulating learning environment based on understanding and respect.	
15. Teaching and learning encourages students to demonstrate their learning in a variety of ways.	
16. Teaching and learning develops the IB learner profile attributes.	

What is inquiry?



Structured inquiry

The IB learner profile states that IB learners strive to be "inquirers", describing the process as developing natural curiosity together with the skills needed to enable them to become autonomous lifelong learners. Inquiry involves an active engagement with the social and physical environment in an effort to make sense of the world, and consequent reflection on the connections between the experiences encountered and the information gathered. Inquiry involves synthesis, analysis and manipulation of knowledge. Structured inquiry describes the strategies and supports that teachers use to facilitate student inquiry that is purposeful and productive.

Depending on the context, students are expected to explore significant issues by formulating their own questions or seeking the answers to prescribed ones. All three programmes expect students, in an age-appropriate way, to be able to:

- design their own inquiries
- assess the various means available to support their inquiries
- proceed with research, experimentation, observation and analysis that will help them in finding their own responses to the issues and in solving problems.

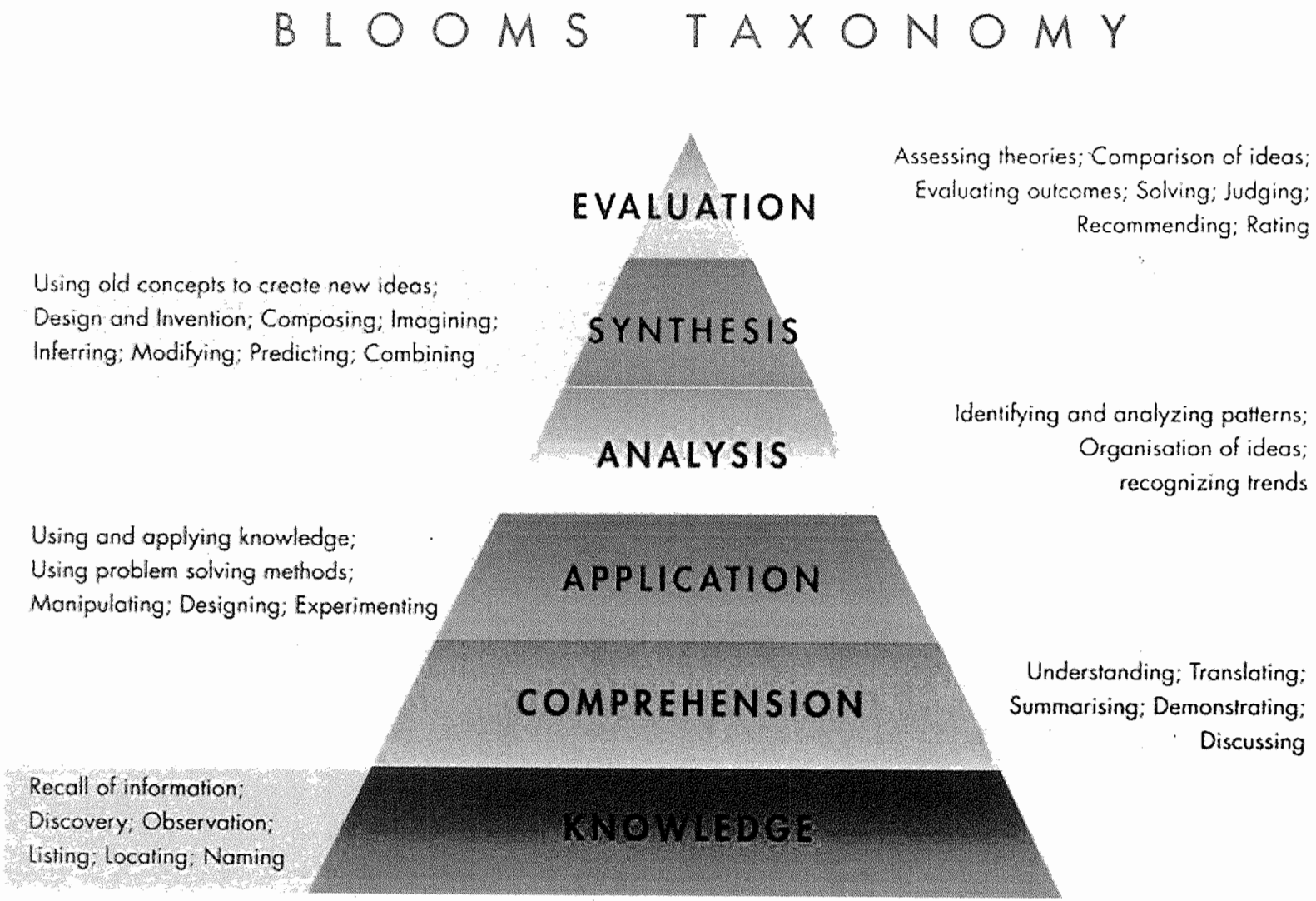
The starting point is students' current understanding, and the goal the active construction of meaning by building connections between that understanding and the new information and experience derived from the inquiry into the new content.

Inquiry, interpreted in the broadest sense, is the process initiated by the student or the teacher that moves the student from their current level of understanding to a new and deeper level of understanding. This often involves many of the following activities:

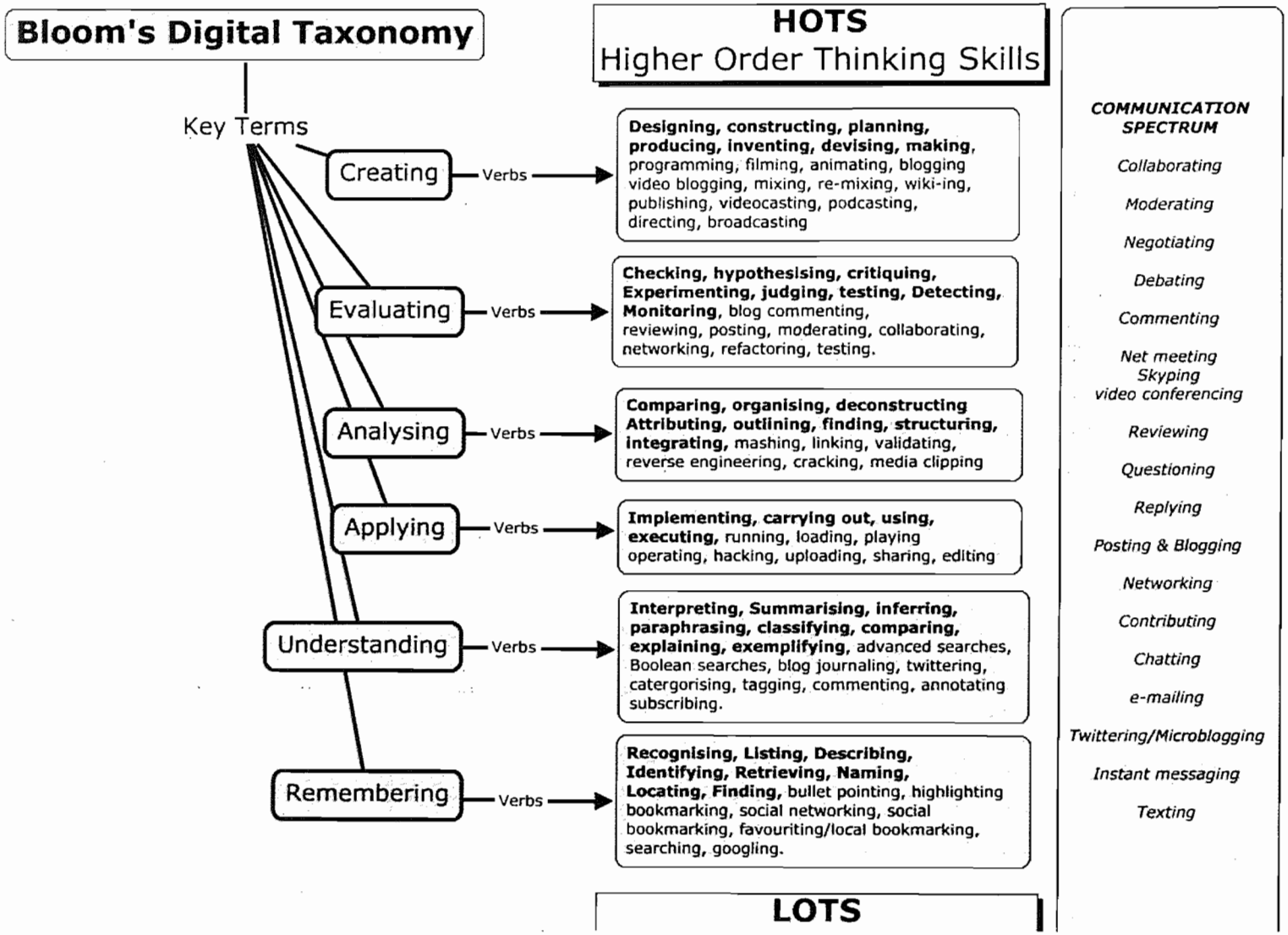
• speculating, exploring, questioning	
• making connections between previous learning and current learning	
• researching	
• developing and testing theories	
• collecting data, reporting findings and constructing explanations	
• clarifying existing ideas and reappraising perceptions of events	
• identifying assumptions	
• taking and defending a position	
• solving problems in a variety of ways	
• analysing and evaluating	
• considering alternative explanations.	

Towards a continuum of international education

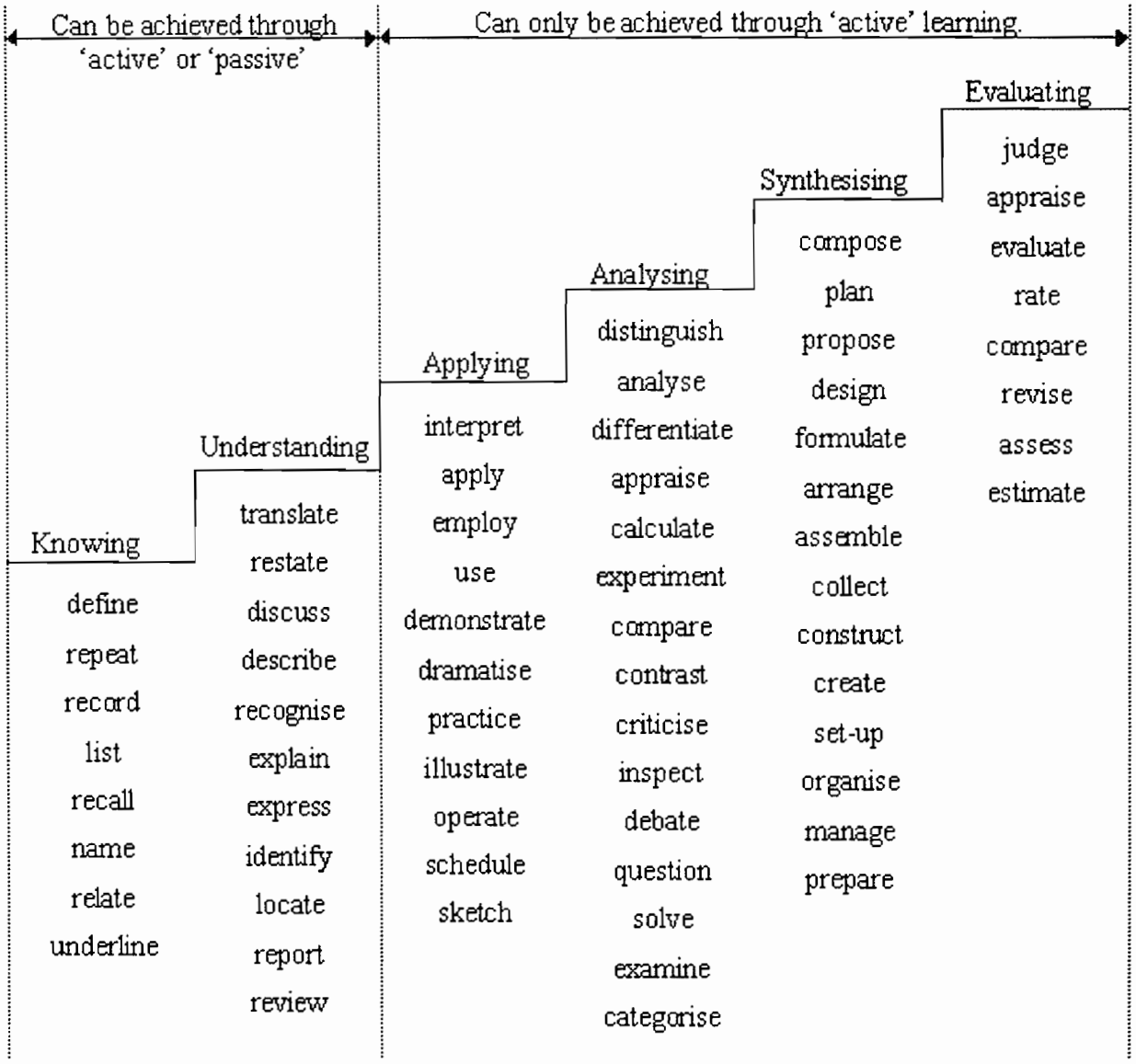
Bloom's Taxonomy



Bloom's Digital Taxonomy



Bloom's Taxonomy of thinking skills



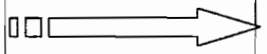
Underline the particular skills students must demonstrate and use in your subject.

BLOOM'S TAXONOMY

Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation

Knowledge

Useful Verbs	Sample Question Stems	Potential activities and products
tell list describe relate locate write find state name	What happened after...? How many...? Who was it that...? Can you name the...? Describe what happened at...? Who spoke to...? Can you tell why...? Find the meaning of...? What is...? Which is true or false...?	Make a list of the main events.. Make a timeline of events. Make a facts chart. Write a list of any pieces of information you can remember. List all the .... in the story. Make a chart showing... Make an acrostic. Recite a poem.



Comprehension

Useful Verbs	Sample Question Stems	Potential activities and products
explain interpret outline discuss distinguish predict restate translate compare describe	Can you write in your own words...? Can you write a brief outline...? What do you think could of happened next...? Who do you think...? What was the main idea...? Who was the key character...? Can you distinguish between...? What differences exist between...? Can you provide an example of what you mean...? Can you provide a definition for...?	Cut out or draw pictures to show a particular event. Illustrate what you think the main idea was. Make a cartoon strip showing the sequence of events. Write and perform a play based on the story. Retell the story in your words. Paint a picture of some aspect you like. Write a summary report of an event. Prepare a flow chart to illustrate the sequence of events. Make a colouring book.

Dalton, J. & Smith, D. (1986) "Extending Children's Special Abilities – Strategies for primary classrooms" pp36-7

BLOOM'S TAXONOMY

Application

Useful Verbs	Sample Question Stems	Potential activities and products
solve show use illustrate construct complete examine classify	Do you know another instance where...? Could this have happened in...? Can you group by characteristics such as...? What factors would you change if...? Can you apply the method used to some experience of your own...? What questions would you ask of...? From the information given, can you develop a set of instructions about...? Would this information be useful if you had a ...?	Construct a model to demonstrate how it will work. Make a diorama to illustrate an important event. Make a scrapbook about the areas of study. Make a paper-mache map to include relevant information about an event. Take a collection of photographs to demonstrate a particular point. Make up a puzzle game suing the ideas from the study area. Make a clay model of an item in the material. Design a market strategy for your product using a known strategy as a model. Dress a doll in national costume. Paint a mural using the same materials. Write a textbook about... for others.

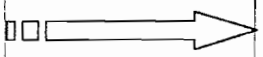
Analysis

Useful Verbs	Sample Question Stems	Potential activities and products
analyse distinguish examine compare contrast investigate categorise identify explain separate advertise	Which events could have happened...? I ... happened, what might the ending have been? How was this similar to...? What was the underlying theme of...? What do you see as other possible outcomes? Why did ... changes occur? Can you compare your ... with that presented in...? Can you explain what must have happened when...? How is ... similar to ...? What are some of the problems of...? Can you distinguish between...? What were some of the motives behind...? What was the turning point in the game? What was the problem with...?	Design a questionnaire to gather information. Write a commercial to sell a new product. Conduct an investigation to produce information to support a view. Make a flow chart to show the critical stages. Construct a graph to illustrate selected information. Make a jigsaw puzzle. Make a family tree showing relationships. Put on a play about the study area. Write a biography of the study person. Prepare a report about the area of study. Arrange a party. Make all the arrangements and record the steps needed. Review a work of art in terms of form, colour and texture.

BLOOM'S TAXONOMY

Synthesis

Useful Verbs	Sample Question Stems	Potential activities and products
create invent compose predict plan construct design imagine propose devise formulate	Can you design a ... to ...? Why not compose a song about...? Can you see a possible solution to...? If you had access to all resources how would you deal with...? Why don't you devise your own way to deal with...? What would happen if...? How many ways can you...? Can you create new and unusual uses for...? Can you write a new recipe for a tasty dish? can you develop a proposal which would...	Invent a machine to do a specific task. Design a building to house your study. Create a new product. Give it a name and plan a marketing campaign. Write about your feelings in relation to... Write a TV show, play, puppet show, role play, song or pantomime about...? Design a record, book, or magazine cover for...? Make up a new language code and write material suing it. Sell an idea. Devise a way to... Compose a rhythm or put new words to a known melody.



Evaluation

Useful Verbs	Sample Question Stems	Potential activities and products
judge select choose decide justify debate verify argue recommend assess discuss rate prioritise determine	Is there a better solution to... Judge the value of... Can you defend your position about...? Do you think ... is a good or a bad thing? How would you have handled...? What changes to ... would you recommend? Do you believe? Are you a ... person? How would you feel if...? How effective are...? What do you think about...?	Prepare a list of criteria to judge a ... show. Indicate priority and ratings. Conduct a debate about an issue of special interest. Make a booklet about 5 rules you see as important. Convince others. Form a panel to discuss views, eg "Learning at School." Write a letter to ... advising on changes needed at... Write a half yearly report. Prepare a case to present your view about...

Concepts drive inquiry

What Is a Concept?

A universal concept is a mental construct that is timeless, universal, and abstract. Although the specific examples of a concept may vary, the general descriptors of the concept will be the same. "Symmetry," as a concept, has many different examples, but the descriptors of symmetry in all of the examples are the same. Examples of symmetry can be found across disciplines, as in art, life science, or music. The descriptors or characteristics include "balance" and "equivalence."

Concepts are a higher level of abstraction than facts in the structure of knowledge. They serve as cells for categorizing the factual examples. Conceptual understanding continues to grow more sophisticated as new examples fill each concept cell. Because higher-level concepts are timeless, they may be studied through the ages. Because they are universal, their examples may be derived from cultures around the world.

It is common in educational circles today to hear the word *theme* being used for the ideas I am defining as concepts. The problem I have found with this practice is that the definition of *theme* is so loose that topics sometimes become confused with concepts. This is a significant problem in integrated curriculum if the goal is higher-level, integrated-unit design. Units centered on a topic alone will only result in coordinated, multidisciplinary curriculum. This means that two or more subjects, or disciplines, are coordinated in instructional time and content to focus on a single topic. Integrated curriculum, described in detail in Chapter 4, requires a conceptual as well as a topical focus if thinking is to be integrated.

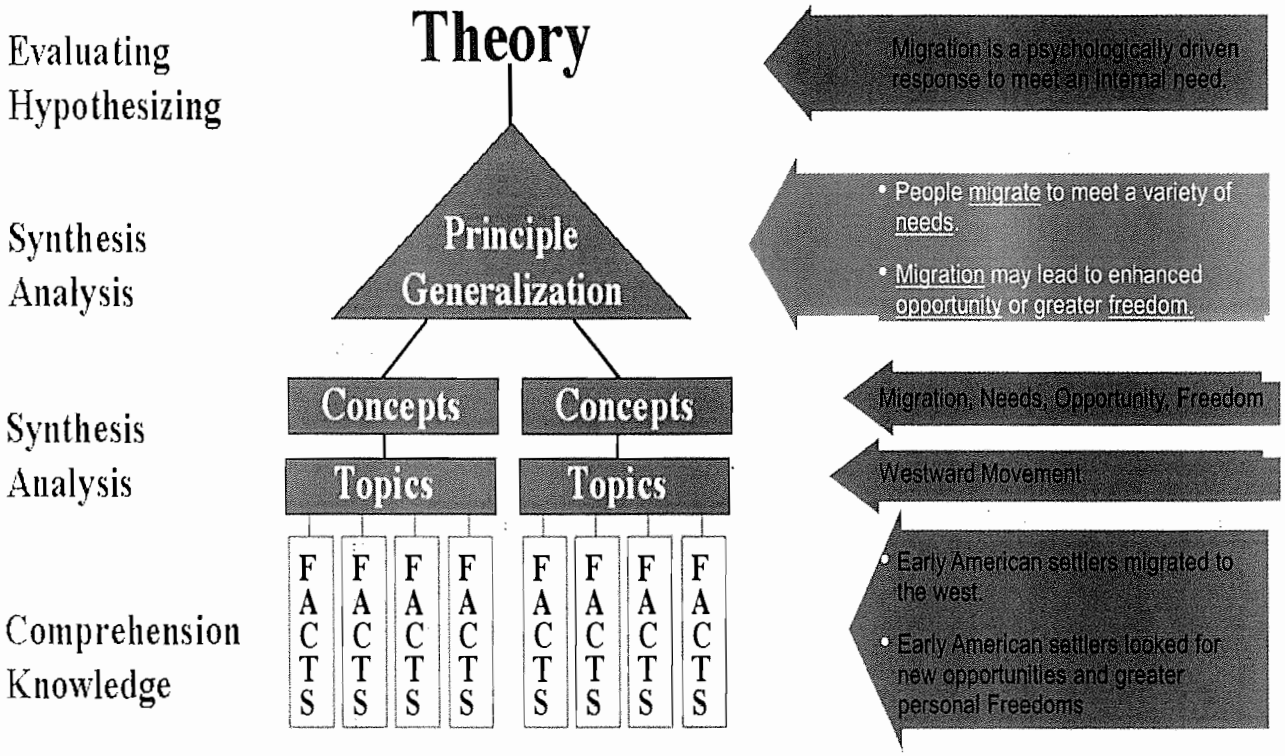
- Broad and Abstract
- Universal in application
- Timeless – carried through ages
- Represented by different examples that share common attributes

Example: Conflict, as a concept, has many different examples, but the examples share the characteristics of "opposing forces" and "friction."

Let's try it. Which of the following are concepts? Apply each of the following terms to the test:

- Conflict
- Family
- Culture
- Change
- Fitness
- Human rights
- China
- Persuasion
- Power
- Revolution
- Model
- Dinosaurs
- Bears
- Cooperation

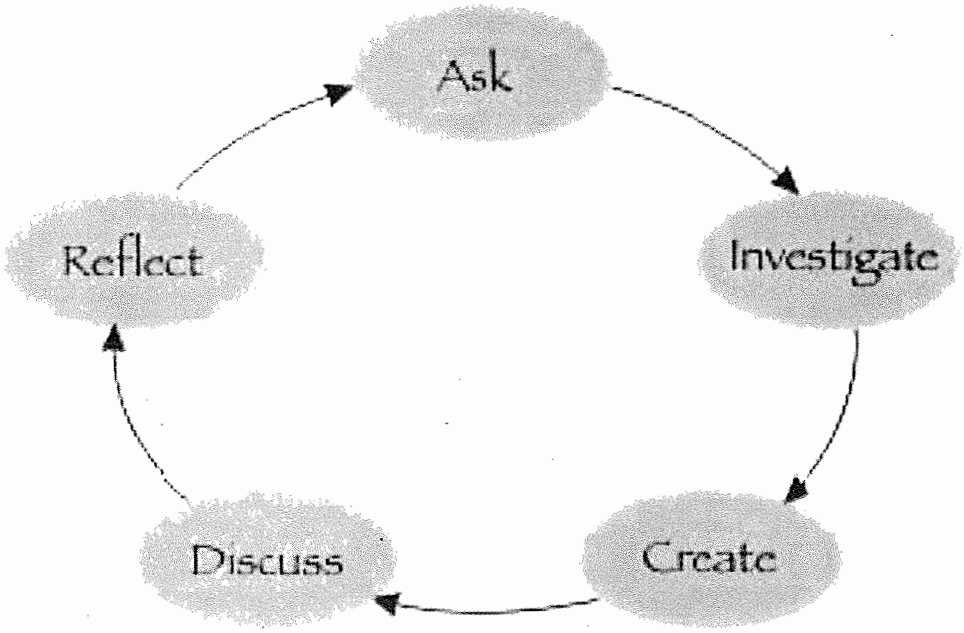
Where do concepts fall in the structure of knowledge?



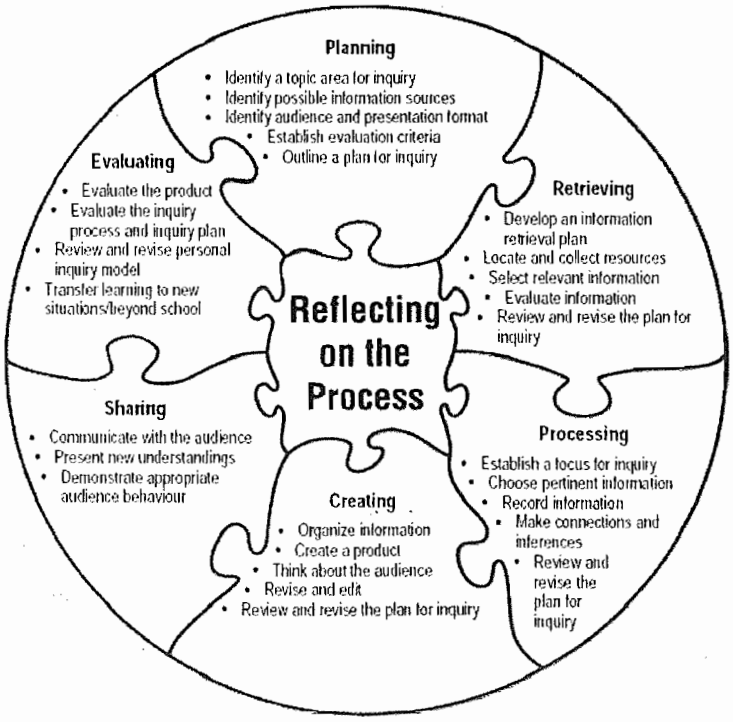
Erikson, Lynn H. Stirring the Head, Heart and Soul: Redefining Curriculum and Instruction. Thousand Oaks, California: Corwin Press Inc.,2001

Inquiry models

Inquiry as a cyclical process



Inquiry Model



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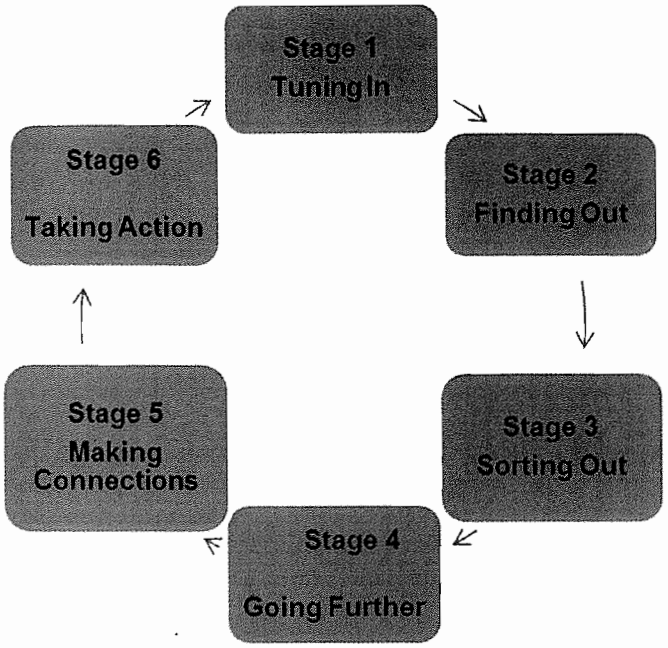


© **Classroom Connections Inquiry Model by Kath Murdoch**

Tuning In

(Getting the children interested in the unit)

Finding Out

(Researching or gathering information)

Sorting Out

(sorting the information into categories)

Going Further

(Adding more interesting information)

Making Connections

(Analyzing & linking to themselves and their environment)

Taking Action

(Making an informed decision to do something)

Task design prompts - GRASPS

The following acronym is based on suggestions from ***Understanding by Design by Grant Wiggins and Jay McTighe***

Goal

- Your task is _____
- The goal is to _____
- The problem or challenge is _____
- The obstacles to overcome are _____

Role

- You are _____
- You have been asked to _____
- Your job is _____

Audience

- Your clients are _____
- The target audience is _____
- You need to convince _____

Situation

- The context you find yourself in is _____
- The challenge involves dealing with _____

Product, Performance, and Purpose

- You will create a _____
  in order to _____
- You need to develop _____
  So that _____

Standards and Criteria for Success

- Your performance needs to _____
- Your work will be judged by _____
- Your product must meet the following standards _____

_____

_____

_____

Learning is something students do, NOT something done to students. **Alfie Kohn**

7 NORMS of Collaboration

1. Promoting a Spirit of Inquiry
Exploring perceptions, assumptions, beliefs, and interpretations promotes the development of understanding. Inquiring into the ideas of others before advocating for one's own ideas is important to productive dialogue and discussion

2. Pausing
Pausing before responding or asking a question allows time for thinking and enhances dialogue, discussion, and decision-making

3. Paraphrasing
Using a paraphrase starter that is comfortable for you – "So..." or "As you are..." or "You're thinking..." – and following the starter with an efficient paraphrase assists members of the group in hearing and understanding one another as they converse and make decisions

4. Probing
Using gentle open-ended probes or inquiries – "Please say more about..." or "I'm interested in..." or "I'd like to hear more about..." or "Then you are saying..." increases the clarity and precision of the group's thinking

5. Putting ideas on the Table
Ideas are the heart of meaningful dialogue and discussion. Label the intention of your comments. For example: "Here is one idea..." or "One thought I have is..." or "Here is a possible approach..." or "Another consideration might be..."

6. Paying Attention to Self and Others
Meaningful dialogue and discussion are facilitated when each group member is conscious of self and of others, and is aware of what (s)he is saying and how it is said as well as how others are responding. This includes paying attention to learning styles when planning, facilitating, and participating in group meetings and conversations

7. Presuming Positive Intentions
Assuming that others' intentions are positive promotes and facilitates meaningful dialogue and discussion, and prevents unintentional put-downs. Using positive intentions in speech is one manifestation of this norm

Adapted from: Garmston, R., and Wellman, B. (2009) *The Adaptive School: A Sourcebook for Developing Collaborative Groups*, 2nd edition. Norwood, MA: Christopher Gordon.

THINK / PUZZLE / EXPLORE

A routine that sets the stage for deeper inquiry

1. What do you <u>think</u> you know about this topic?
2. What questions or <u>puzzles</u> do you have?
3. What does the topic make you want to <u>explore</u> ?

Purpose: What kind of thinking does this routine encourage?

This routine activates prior knowledge, generates ideas and curiosity and sets the stage for deeper inquiry.

Application: When and where can it be used?

This routine works especially well when introducing a new topic, concept or theme in the classroom. It helps students take stock of what they already know and then pushes students to identify puzzling questions or areas of interest to pursue. Teachers can get a good sense of where students are on a conceptual level and, by returning to the routine over the course of study, they can identify development and progress. The third question is useful in helping students lay the ground work for independent inquiry.

Launch: What are some tips for starting and using this routine?

With the introduction of new topic—for example, earth, leaves, fractions, Buddhism—the class can engage in the routine together to create a group list of ideas. Between each phase of the routine, that is with each question, adequate time needs to be given for individuals to think and identify their ideas. You may even want to have students write down their individual ideas before sharing them out as a class. In some cases, you may want to have students carry out the routine individually on paper or in their heads before working on a new area.

Keep a visible record of students' ideas. If you are working in a group, ask students to share some of their thoughts and collect a broad list of ideas about the topic on chart paper. Or students can write their individual responses on post-it notes and later add them to a class list of ideas.

Note that it is common for students to have misconceptions at this point—include them on the list so all ideas are available for consideration after further study. Students may at first list seemingly simplistic ideas and questions. Include these on the whole class list but push students to think about things that are truly puzzling or interesting to them.

Generate, Sort, Connect, Elaborate: Concept Maps

A routine for organizing one's understanding of a topic through concept mapping

Select a topic, concept, or issue for which you want to map your understanding.

- Generate a list of ideas and initial thoughts that come to mind when you think about this particular topic/issue.
- Sort your ideas according to how central or tangential they are. Place central ideas near the center and more tangential ideas toward the outside of the page.
- Connect your ideas by drawing connecting lines between ideas that have something in common. Explain and write in a short sentence how the ideas are connected.
- Elaborate on any of the ideas/thoughts you have written so far by adding new ideas that expand, extend, or add to your initial ideas.

Continue generating, connecting, and elaborating new ideas until you feel you have a good representation of your understanding.

Purpose: What kind of thinking does this routine encourage?
This routine activates prior knowledge and helps to generate ideas about a topic. It also facilitates making connections among ideas. Concept maps help to uncover students' mental models of a topic in a non-linear way.

Application: When and where can it be used?
This routine can be useful as a pre-assessment before the beginning of a unit of study if students already have a lot of background information about the topic. Conversely, it can also be useful as a post or ongoing assessment to see what students are remembering and how they are connecting ideas. Individual maps can be used as the basis for construction of a whole classroom map. Maps can also be done progressively, with students adding to their maps each week of the unit.

Launch? What are some tips for starting and using this routine?
Depending on how much familiarity students have with concept maps, you may need to demonstrate making a concept map using this routine with the whole class. However, if students are relatively familiar with the idea of concept maps, you can launch right into the routine explaining that students will be making concept maps but in a structured way. Give time for students to complete each step of the routine before moving on to the next step. It isn't necessary that students generate an exhaustive list of all their ideas initially, but make sure they have time to generate a rich and varied list before moving on. Tell students that at any point they can add new ideas to their list and incorporate them into their map. If you are adding to a map over time, you might want to have students use a different color pencil each time they make additions. Explaining and discussing maps with partners helps students to consolidate their thinking and gain other perspectives.

Understanding Map

'Peeling the Fruit' – A Map for Tracking and Guiding Understanding

1. Put some version of the map up in a convenient location or give learners copies. See example below and notes about different ways of using the map.
2. Briefly state that the group will be tracking progress and planning with the map from time to time. Note how the map uses the metaphor of 'peeling the fruit', getting familiar with the surface of something, seeking puzzles and mysteries to investigate, and pursuing these in various ways to arrive at core understandings.
3. Refer to the map to choose next steps and mark progress from time to time during the exploration of a topic (no need to do everything every time). Use it as a way of thinking about what routines to use or simply what kind of conversation or other activity to have.
4. When the map is used collectively by a class, you may want to invite students to put up Post-its on the map over time to mark insights associated with any of the map elements.

Purpose: Why use this map?

We often want to develop learners' understanding of a complex topic over days or weeks. This map can help. It's not a routine but a way of planning and tracking over time the exploration of a topic. It can help in choosing good routines too.

Application: When and where can I use this map?

Whenever there's a topic that calls for a broad and rich understanding and learners have enough time to look at it in different ways – anything from a single long lesson to several lessons or a unit. You can use it with students collectively, to help them maintain a bird's eye view of progress through a topic and to make with them good choices about what to do next. You can use it yourself, to plan topics and to track progress. You can also give copies to students for their individual self-management in pursuing a general class topic or individual projects.

Launch: What are some tips for starting and using this thinking map?

Explain that the map is for tracking and guiding the exploration of the topic. Explain the metaphor briefly. Invite learners to help chart progress by using the map.

You can create a giant version of the map to put on the wall of a classroom (see diagram below), or just put labels up for the categories if it's easier to organize on the wall, or personalize the process in some other way. If you're tracking two or three topics at the same time or multiple groups you might: have two or three wall maps, color code paths on a single map, give learners page-size copies to track their own progress, or invent something else. Whatever works! The main idea is to make visible the developing understanding to mark progress and choose next steps.

It usually makes sense to start with the 'skin' and go to 'getting under the skin' with mysteries and then on from there to 'substance' and toward the 'core'. You need not use all of the 'substance' approaches – whatever fits – and there's no fixed order. You can go back to something and add at any time of course!

WHAT MAKES YOU SAY THAT?

Interpretation with Justification Routine

1. What's going on?

2. What do you see that makes you say that?

Purpose: What kind of thinking does this routine encourage?

This routine helps students describe what they see or know and asks them to build explanations. It promotes evidential reasoning (evidence-based reasoning) and because it invites students to share their interpretations, it encourages students to understand alternatives and multiple perspectives.

Application: When and where can it be used?

This is a thinking routine that asks students to describe something, such as an object or concept, and then support their interpretation with evidence. Because the basic questions in this routine are flexible, it is useful when looking at objects such as works of art or historical artifacts, but it can also be used to explore a poem, make scientific observations and hypothesis, or investigate more conceptual ideas (i.e., democracy). The routine can be adapted for use with almost any subject and may also be useful for gathering information on students' general concepts when introducing a new topic.

Launch: What are some tips for starting and using this routine?

In most cases, the routine takes the shape of a whole class or group conversation around an object or topic, but can also be used in small groups or by individuals. When first introducing the routine, the teacher may scaffold students by continually asking the follow-up questions after a student gives an interpretation. Over time students may begin to automatically support their interpretations with evidence with out even being asked, and eventually students will begin to internalize the routine.

The two core questions for this routine can be varied in a number of ways depending on the context: What do you know? What do you see or know that makes you say that? Sometimes you may want to preceded students' interpretation by using a question of description: What do you see? or What do you know?

When using this routine in a group conversation it may be necessary to think of alternative forms of documentation that do not interfere with the flow of the discussion. One option is to record class discussions using video or audio. Listening and noting students' use of language of thinking can help you see their development. Students words and language can serve as a form of documentation that helps create a rubric for what makes a good interpretation or for what constitutes good reasoning.

Another option is to make a chart or keep an ongoing list of explanations posted in the classroom. As interpretations develop, note changes and have further discussion about these new explanations. These lists can also invite further inquiry and searches for evidence. Other options for both group and individual work include students documenting their own interpretations through sketches, drawings, models and writing, all of which can be displayed and revisited in the classroom.

CLAIM / SUPPORT / QUESTION

A reasoning routine

1. Make a **claim** about the topic	→	**Claim:** An explanation or interpretation of some aspect of the topic.
2. Identify **support** for your claim	→	**Support:** Things you see, feel, and know that support your claim.
3. Ask a **question** related to your claim	→	**Question:** What's left hanging? What isn't explained? What new reasons does your claim raise?

Purpose: What kind of thinking does this routine encourage?

The routine helps students develop thoughtful interpretations by encouraging them to reason with evidence. Students learn to identify truth claims and explore strategies for uncovering truth.

Application: When and where can I use it?

Use *Claim Support Question* with topics in the curriculum that invite explanation or are open to interpretation.

Launch: What are some tips for starting and using this routine?

The routine can work well for individuals, in small groups and for whole group discussions. Begin by modeling the routine: Identify a claim and explore support and questions in a whole group discussion. On the board make one column for SUPPORT and one column for QUESTIONS. Ask the class for evidence that either supports a claim, or questions the claim and write it in the appropriate column. Take turns using the routine so that each student makes a claim, identifies support and asks a question.

Following each person's report, take a moment as a group to discuss the topic in relation to the claim before moving on to the next person. Be patient as students take a few moments to think. You may need to probe further by asking: What are some other questions you might want to ask about this statement? or Can you think of reasons why this may be true? Encourage friendly disagreement – once a student comes up with an alternative perspective about a claim, encourage other students to follow. The questions can challenge the plausibility of the claim, and often lead to a deeper understanding of the reasoning process. Let students know it is fine to disagree with one another's reasons and encourage them to come up with creative suggestions for support and questioning.

After everyone has had a turn, reflect on the activity. What new thoughts do students have about the topic?

QUESTION STARTS

A routine for creating thought-provoking questions

1. Brainstorm a list of at least 12 questions about the topic, concept or object. Use these question-starts to help you think of interesting questions:

Why...?	*How would it be different if... ?*
What are the reasons...?	*Suppose that...?*
What if...?	*What if we knew...?*
What is the purpose of...?	*What would change if...?*

2. Review the brainstormed list and star the questions that seem most interesting. Then, select one or more of the starred questions to discuss for a few moments.

3. Reflect: What new ideas do you have about the topic, concept or object that you didn't have before?

Purpose: What kind of thinking does this routine encourage?

This routine provides students with the opportunity to practice developing good questions that provoke thinking and inquiry into a topic. It also helps students brainstorm lots of different *kinds* of questions about a topic. The purpose of asking deep and interesting questions is to get at the complexity and depth of a topic. The purpose of brainstorming varied questions about a topic is to get at the breadth, and multi-dimensionality of a topic.

Application: When and where can it be used?

Use Question Starts to expand and deepen students' thinking, to encourage students' curiosity and increase their motivation to inquire. This routine can be used when you are introducing a new topic to help students get a sense of the breadth of a topic. It can be used when you're in the middle of studying a topic as a way of enlivening students' curiosity. And it can be used when you are near the end of studying a topic, as a way of showing students how the knowledge they have gained about the topic helps them to ask ever more interesting questions. This routine can also be used continuously throughout a topic, to help the class keep a visible, evolving list of questions about the topic that can be added to at anytime.

Launch: What are some tips for starting and using the routine?

Before using Question Starts, you might want to ask students what *they* think makes a good question. Then, when you show the Question Starts, explain that this routine is a tool for asking good questions. Start the routine by providing a topic– Stockholm, a compass, the Equator, good sportsmanship. Ask them to use the Question Starts to generate a list of questions about the topic. Initially, it's best to work together as an entire group. Once students get the hang of the routine, you can have them work in small groups, or even solo. Or mix it up. For example, do step 1 as a whole class, do step 2 in pairs, and step 3 as a whole class again.

After students finish generating questions, you can use the questions they created in a variety of ways: pick one of the questions to investigate further, have a discussion about some of the questions, give students information to read about the topic, ask them to investigate it in other ways, or do nothing further as simply creating the list of questions is worthwhile since it gives students a sense of the breadth of a topic and sparks curiosity about it.

Students' questions can be written down and recorded so that they are listed for all to see. If students are working solo, they can keep their list of questions in a journal, or you can create a "collage" out of students' individual lists and display it on the classroom wall.

Using Multiple Intelligences in Testing and Assessment

Although Howard Gardner's theory of multiple intelligences (MI) is over two decade old, teachers are still trying to find the best way to use this theory to assess students with different styles of learning and varied academic strengths. Multiple Intelligences shape the way students understand, process, and use information.

Gardner groups student capabilities into eight broad categories (each student's unique learning style is a combination of these intelligences):

- **Logical/mathematical** (uses numbers effectively)
- **Visual/spatial** (is artistically or spatially perceptive)
- **Bodily/kinesthetic** (excels at tasks that require physical movement)
- **Musical** (perceives and/or expresses musical forms and patterns)
- **Linguistic** (uses words effectively)
- **Interpersonal** (responds well to others)
- **Intrapersonal** (is reflective and inner-directed)
- **Naturalist** (makes distinctions in the natural world)

Since no single approach to teaching and assessment can possibly work best for every student, teachers face a challenge. What's the best way to match assessments to students' learning styles?

Assessing Multiple Intelligences
Of course, assessment should reflect the diversity of intelligences and learning styles in your classroom. For example, students who are good at spatial learning might not display the full range of their knowledge on an essay test. In fact, traditional testing methods are inherently biased in favor of students with strong linguistic and mathematical skills. Advocates of MI theory suggest that teachers supplement their traditional assessment methods with assessment strategies that evaluate student progress in an inclusive, meaningful way.

So, how can you use the theory of multiple intelligences to assess student achievement in your classroom? The MI approach to testing is closely related to authentic assessment. This approach enables students to demonstrate the depth of their understanding, connect their classwork to real-life experiences, and apply their knowledge to new situations.

MI theorists offer the following tips:

- Emphasize ongoing assessment and progress. Continue to ask if and how students have improved their skills.
- Introduce assessment to your students as a regular part of classroom life. Make assessment a part of the learning process, not a stressful, intimidating "event."
- Try to use instruments, tools, and procedures that embrace some, if not all, of the multiple intelligences.
- Use a wide range of assessment tools to measure students' skills and abilities.
- Give lots of feedback!

Build Your Own Assessment Repertoire

To create successful assessment strategies, familiarize yourself with your students' individual learning styles. Knowing how your students learn best can help you choose approaches that will reach them most effectively. Here are some specific strategies that can make assessment productive and fun:

Linguistic

- Ask students to write in a journal regularly.
- Give oral exams and/or essay tests.
- Emphasize creative writing – have students write poems, plays, and stories.

Logical/Mathematical

- Assign science labs and experiments.
- Have students complete logic problems and games.

Bodily/Kinesthetic

- Challenge students to write and perform plays.
- Have students build models or use other hands-on techniques to show what they learned.

Visual/Spatial

- Invite students to create collages, murals, and posters.
- Encourage students to illustrate their ideas using maps, charts, and graphs.
- Help students use school equipment to make a video or slide show.

Interpersonal

- Stage a classroom debate.
- Have students work collaboratively to brainstorm and prepare a project.

Intrapersonal

- Ask students to identify their own academic strengths and weaknesses.
- Have students think of personal goals and give progress reports.

Musical

- Challenge students to identify and explain patterns in music or poetry.
- Ask students to write new lyrics to familiar melodies or to compose a new song.

Naturalist

- Ask students to keep environmental journals and to share their observations.
- Invite students to lead classmates on a nature walk to point out interesting plants and animals they found during independent study.
- Note that many of these assessment strategies evaluate more than one kind of intelligence. You can use strategies like these and other combinations of projects, performances, and portfolios to assess students' progress.

There is no "right" way to use multiple intelligences in testing and assessment. You don't have to overhaul your whole curriculum. But you can make an effort to address each student's strengths and weaknesses by using creative alternatives to traditional testing in your classroom.

Multiple Intelligences Chart

How do you ensure all of your students' intelligences are being tapped? Here is a list of activities that speak to each type of intelligence.

Verbal-Linguistic	Logical-Mathematical	Visual-Spatial	Bodily-Kinesthetic
choral speaking declarizing storytelling retelling speaking debating presenting reading aloud dramatizing book making nonfiction reading researching listening process writing writing journals	problem solving measuring coding sequencing critical thinking predicting playing logic games collecting data experimenting solving puzzles classifying using manipulatives learning the scientific model using money using geometry	graphing photographing making visual metaphors making visual analogies mapping stories making 3D projects painting illustrating using charts using organizers visualizing sketching patterning visual puzzles	hands on experiments activities changing room arrangement creative movement going on field trips physical education activities crafts dramatizing using cooperative groups dancing
Musical	**Interpersonal**	**Intrapersonal**	**Naturalistic**
humming rapping playing background music patterns form playing instruments tapping out poetic rhythms rhyming singing	classroom parties peer editing cooperative learning sharing group work forming clubs peer teaching social awareness conflict mediation discussing cross age tutoring study group brainstorming	personal response individual study personal goal setting individual projects journal log keeping personal choice in projects independent reading	reading outside cloud watching identifying insects building habitats identifying plants using a microscope dissecting going on a nature walk build a garden studying the stars bird watching collecting rocks making bird feeders going to the zoo

Types of Formative Assessment

There is a large range of formative assessment methods available. These include:

Question and Answer in the Lesson

This is perhaps the most commonly used method and is almost instinctive for teachers. It gives instant feedback, can be used to develop motivation but is largely ephemeral – that is to say that it is momentary and difficult to record.

Short Tests and Quizzes

These are either from textbooks or devised by the teacher. These are informal, can be fun and marks can be simply recorded. Used with care they can become part of every day teaching and learning.

Homework Exercises

These vary in purpose, design and complexity. 'Purpose' is the key word here. Students will make good use of homework if they feel it is useful, for example, preparation of material for a class discussion, seeing how a piece of writing ends, developing a skill, are all appealing tasks.

Skills Assessment using Formal Assessment Criteria

These may be the foundation for many skills-based courses. This method requires experience in 'on the hoof' assessment and systematic recording.

Observation of Performance

This is often used in the arts such as music and skill assessment such as team and leadership exercises. It needs expert and experienced assessors.

Assignments

This term spans a vast range of tasks but an example might be individual research assignments say for a group project. A very useful and increasingly used method, especially in conjunction with homework. May involve library and internet investigations, visits and interviews. Difficult to manage and assess.

Projects

Increasingly used in modern education as it is felt that developing your own learning material/methods gives you an 'ownership' of your own learning experience. The assessment methods of the various project components need careful design and clear communication to the students.

Written Questions / Exercises with Short, Extended or Multiple-choice Answers

Very widely used. Easy to design, mark and assess.

Simulations, Business Games

Almost guaranteed to produce lively learning sessions! Can teach a number of skills imaginatively and effectively. The better ones contain useful directions to possible methods of assessment. May well be time-consuming.

Conferencing / Reviews / Audit

This involves sitting down with learners and reviewing their written work/homework/progress in general. A very useful and beneficial process for teachers and students. Can be used to introduce care, involvement and motivation into the teacher-learner relationship. Three points to watch when operating it as a method.

1. It can be time consuming as you have to give all students a review session. (If you do not – those who are omitted will feel rejected!)

2. If you do it in class you must ensure that those not involved have something useful to be getting on with.

3. Make notes on student performance immediately after the review, not during it.

Exit Tickets

1. Give students "tickets" – small pieces of paper designed to look like tickets, but with space for writing.
2. Ask students two questions. One that requires a factual answer about the big idea of today's lesson, but in their own words. A second question should require more explanation of a concept.

3. Give students five minutes at the end of class to write their answers. Their names do not go on these exit tickets.

4. They must give you an Exit Ticket to leave class for the day.

5. Analyze the tickets to learn how many students got the big idea and how they understand it or misunderstand it. Photocopy 4-6 on a single sheet of paper for your portfolio. Select ones that you learned something about your students from that you didn't know before reading the Exit Tickets.

One-Minute Papers

1. Give students an open-ended question and one to three minutes to write their answers.

2. Good questions: What is the most important thing we discussed today? Or What was the most confusing idea presented today?

3. Collect the papers and use for promoting discussion, identifying misconceptions, or confusion.
4. Photocopy samples of the papers to use with your reflections.

Problem Solving Observation

1. Give the class a complex problem to solve. Ask them to work in pairs.

2. Good problems will have more than one part and will require students to explain their thinking to each other. It may be helpful to use problems that require students to show their thinking in more than one way. Examples of showing their thinking in more than one way might include graphing, diagramming, explaining how someone with a different perspective might answer the question, and generating examples.

3. Join one of the groups while they work. Have in mind that you are observing and focus in a way that you can write down later what you observed. You may find it helpful to jot down 2 or 3 words during this observation to prompt your recall later.

4. Prompt students to explain their thinking to each other. Ask them to say aloud what they are thinking while they are solving the problem. Prompt them with questions such as "Why" "how are you deciding to" or "What were you thinking about when you did that."

5. As soon as practical jot down notes about what you observed-especially including notes about student's problem solving process and what they understand about the process.

Document information amalgamated from:

http://rmit.net.au/browse;ID=izr6vvr1b3k1

http://taosschools.org/THS/School%20Improvement/CIEDipTTModule7TypesofFormativeAssessment.pdf

e3t.org/formassess/assets/Formative%20Assessment%20Strategies.doc [in turn adapted from **the Millersville University CIRQL Project]**

www.k12.wa.us/.../Form_Assess_Tactic%20OSPI%20Jan%202009.ppt

Assessment strategies and tasks

Introduction

Assessment strategies

The guide MYP from principles into practice, 2008 identifies several broad groups of strategies that can be used in the assessment of student work. These broad groups are as follows.

- Observation - Teachers may choose to observe all students.
- Selected response - Tests and quizzes are the most familiar examples.
- Open-ended tasks - Teachers present students with a stimulus and ask them to communicate an original response.
- Performance - Teachers devise assessment tasks that enable students to demonstrate their knowledge, skills, understandings and attitudes in real-world contexts. (The MYP uses the term "performance" in its widest sense to describe all forms of assessment where students are assessed on their ability to demonstrate predetermined learning objectives.)
- Process journals - Teachers engage students in meaningful and purposeful reflection on the processes of learning.
- Portfolio assessment - involve students in their own learning and assessment

Assessment tasks

The above assessment strategies, and others, can all be used to develop suitable and appropriate assessment tasks. Tasks will be specific to the MYP unit of work, although various categories of task exist that are broadly represented by the following list.

- Compositions—musical, physical, artistic
- Creations of solutions or products in response to problems
- Essays
- Examinations
- Questionnaires
- Investigations
- Research
- Performances
- Presentations—verbal (oral or written), graphic—through various media

REFLECTION – TRY IT! – SOME POSSIBLE QUESTIONS TO USE WITH STUDENTS AT THE END OF A UNIT. SUBSTITUTE 'WORKSHOP' FOR 'UNIT', AND FILL SOME OF IT IN!

Answer these questions thoughtfully as a starting point for your self-evaluation. Please put these reflections in your portfolio with your self-evaluation.
Name: **Date** *The work in this unit of which I am most proud is:* *because:*
The skill I feel I improved most on is:
A challenge I need to do more work on is:
The material I worked hardest on during this unit was: *The material I feel I learned the best was:*
Material I felt less confident about was:
Some of my most effective learning during this unit has come from: (participating in group work? participating in discussion and lecture-type presentation? reading? note-taking? reviewing my notes and reflecting on my understanding? working on problems independently? working on problems in groups? research? talking with teachers? talking with classmates? other?)
Some less effective ways of learning have been:

- Modified from Dr Lance Laird – open source available at: 192.211.16.13/curricular/mnm2001/**reflection**.html

The most important thing I learned about myself in this unit was ...

Things I wish I had done better include ...

I seem to learn more when I ...

A little honesty ☺: *I missed _____ classes, _____ homeworks _____ during this unit.*

The effect this had on my learning was:

Learning techniques I'd like to improve include:

What happened with your preparation skills this unit? How have you learned to prepare more usefully for classes? What are the most constructive ways you feel you contributed to classes?
I feel I contributed most to class in this way:

The most significant development in my analytical and literary criticism skills has been:

Looking back over the texts, my notes, papers, homework, assignments, and research, these are some of the major themes that caught my attention:

The most important new perspective I gained about literature / a particular text (specify) was ...

- Modified from Dr Lance Laird – open source available at: 192.211.16.13/curricular/mnm2001/**reflection**.html

I can now say that literature is not simply ...

because ...

How has your understanding of literature and its themes, techniques, expression etc become more complex as a result of this unit?
I found new ways to think about ...

through ...

I learned from doing my major assessment / research project etc that ...

I learned from presenting my work in front of class that ...

The most important things I learned in class were...

The most important things I learned in group work were ...

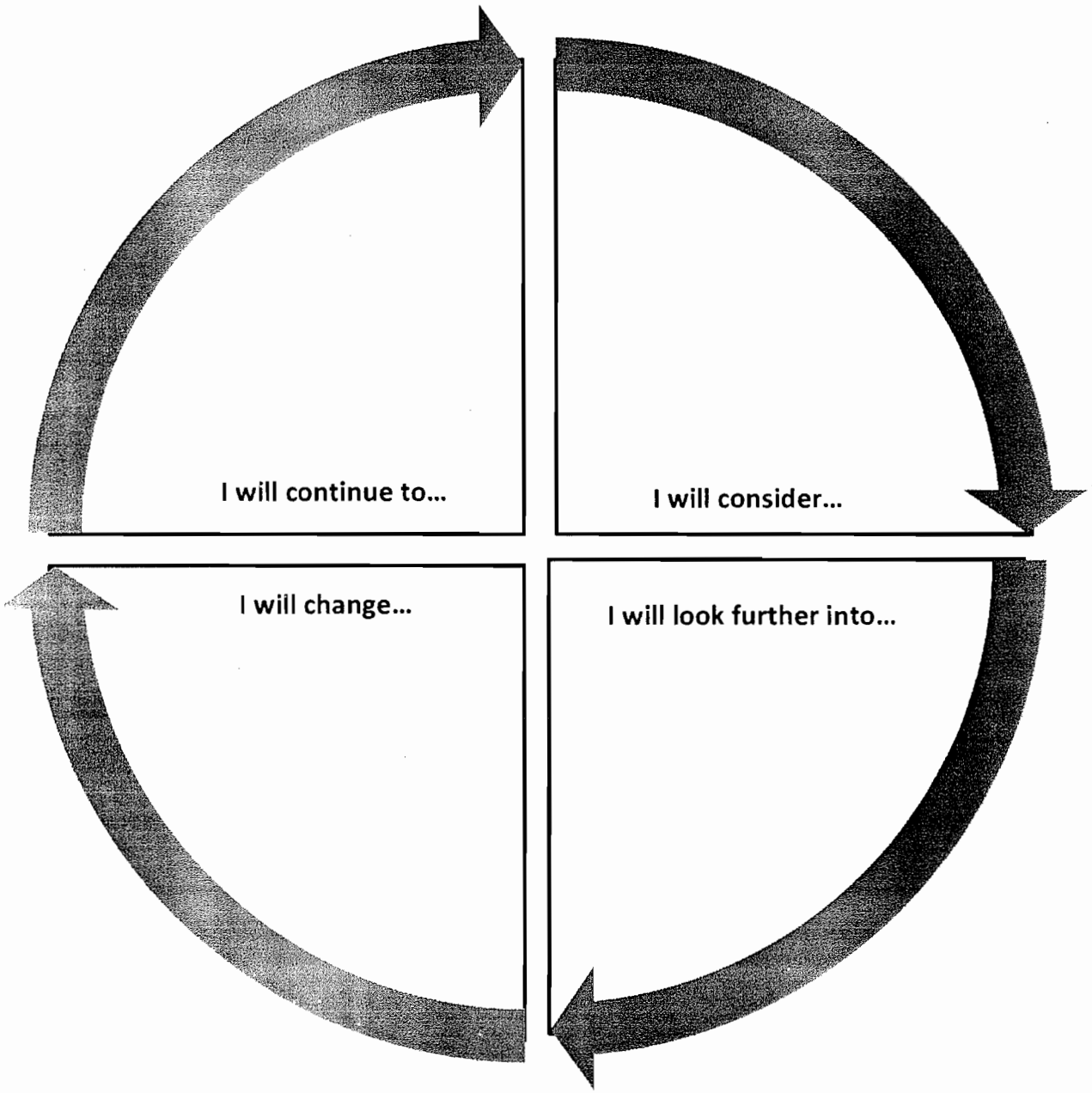
The most important things I gained from my peers in this unit were ...

The most important things I gained from independent work in this unit were...

- Modified from Dr Lance Laird – open source available at: 192.211.16.13/curricular/mnm2001/**reflection**.html

Reflection goals

Consider the following in relation to your personal inquiry goals and what strategies may be significant to your department.



Learner-Centered Instruction

(Paul Kim)

Model	Attributes
Inquiry	• A learner-centered, active learning approach focusing on questioning, critical thinking, and problem solving • Follows the principle that involving learners will help them better understand the lessons
Resource-based learning	• Learners actively engage in multiple resources (print and non-print) • Learners responsible for selecting resources (e.g. Internet, books, human) that appeal to their personal learning preferences, interests and abilities • Learners become active learners as they use a wide range of materials to investigate subject material prescribed within their classroom curriculum
Cognitive Apprenticeship	• Learners work in teams on projects or problems with close scaffolding of the teacher • Guided participation helps the learner achieve tasks that independently would be too hard or complicated. • The task or goal is to form a process of thinking - or something that is intangible into something tangible • Teachers usually model or scaffold the skills or tasks in the beginning. Once learners begin to understand, the modeling and scaffolding is reduced. This allows learners to accomplish the task on their own and only ask for help when needed.
Problem-based learning	• Focuses on the process of problem solving, critical thinking in situated contexts, and acquiring knowledge. It is inquiry-based when learners are active in creating the problem • Emphasis is placed on using communication, cooperation, and resources to formulate ideas and develop reasoning skills • Knowledge is constructed within each individual or community based on the learner's or community's prior knowledge, values, beliefs, and perspectives. • Learning occurs through social interactions whereby an outside source can help individuals extend their learning • Activities are organized around achieving a shared goal (project).
Project-Based Learning	• Focuses on developing a product or creation • Engages learners by starting with concrete and solving hands-on, real-world problems • Learners are usually provided with specifications for a desired end product (e.g a specific • project, such as building a rocket or designing a web site) • The learning process is more oriented to following correct procedures. • Teachers are more likely provide expert guidance, feedback and suggestions (e.g. modeling, scaffolding) to help learners achieve the final product. This is provided according to learner needs and within the context of the project • Activities are organized around achieving a shared goal (project)
Collaborative Learning	• Learners placed in groups or pairs for the purpose of achieving a common academic goal • Learners are responsible for one another's learning as well as their own. Thus, the success of one learner helps other learners to be successful • Does not require face-to-face interaction as collaborative learning can take place across the Internet
Cooperative Learning	• It is a specific kind of collaborative learning, where learners work together in *small* groups on a structured activity. They are individually accountable for their work and are responsible for helping teammates learn • Cooperative groups work face-to-face and learn to work as a team
Constructivism	• Founded on the premise that reflecting on personal experiences allows learners to construct their own understanding of the world • Teachers focus on making connections between facts and fostering new understanding in learners • Teachers rely heavily on open-ended questions and promoting extensive dialogue among learners • Learners encouraged to analyze, interpret, and predict information

The role of the teacher